

Implicit Adaptive Mesh Refinement for 2D Resistive Magnetohydrodynamics

Bobby Philip ^{*}, Luis Chacón [†], and Michael Pernice [‡]

Application of implicit adaptive mesh refinement (AMR) to a 2D reduced resistive magnetohydrodynamics (MHD) model is described. This challenging, multi-scale, multi-physics model is of interest for the understanding of magnetically-confined plasmas. AMR is employed to resolve extremely thin current sheets, essential for an accurate macroscopic description. Implicit time stepping allows us to accurately follow the dynamical time scale of the developing magnetic field, without being restricted by fast Alfvén time scales. At each time step, the large-scale system of nonlinear equations is solved by a Jacobian-free Newton-Krylov method together with a physics-based preconditioner. Each block within the preconditioner is solved optimally using the Fast Adaptive Composite grid method, which can be considered as a multiplicative Schwarz method on AMR grids.

In this talk, we will discuss the application of the algorithm to several challenging MHD applications. It will be demonstrated that the approach behaves optimally (scalably) under grid refinement, and that numerical error in the solution is independent of the number of refinement levels. Furthermore, for the applications explored, the AMR approach results in substantial CPU savings (more than 80%) vs. what would be required by an equivalent uniform-mesh simulation.

^{*}Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545. Research supported by LANL LDRD program

[†]Oak Ridge National Laboratory, Oak Ridge, TN 37831, Research supported by OASCR

[‡]Center for Advanced Modeling and Simulation, Idaho National Laboratory, Idaho Falls, ID 83415-2211